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# Professional actions of novice teachers in the context of teaching and learning geometry

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*This paper aims to describe the professional actions of beginning teachers in the context of teaching and learning geometry. Using different theoretical tools, our research is based on the observation of lessons (with students aged between 6 and 11) delivered by beginning teachers in France. The paper seeks to show how the specific context of geometry impacts on professional actions especially among beginning teachers.*

*Keywords: Geometry education, teacher professional actions, beginning teachers.*

The first part of the article describes the theoretical background and research questions. The second part is dedicated to the methodology and results from several observations of novice teachers in the context of teaching geometry. The final part of the article is an opportunity to discuss with new perspectives in the context of pre and in-service teacher training.

## **Theoretical framework in terms of *teacher professional actions***

This research takes part of a bigger collaborative research which deals with different fields (mathematics, literature, sciences...); the goal is to study conditions of development of teacher professional actions through the follow-up of a cohort of dozen of beginning teachers. In order to compare analyses we need a common theoretical framework, we describe it in next part.

Jorro (2002) distinguishes *generic teaching actions* from *professional actions*<sup>1</sup>. The former are attached to a collective culture shared by a community such as stereotyped actions (*writing on the blackboard, calling a student up to the black-board, putting a finger to the lips meaning quiet, etc.*) while the latter are more a singular and contextual conception. We refer mainly to Bucheton and Soulé (2009) to define more precisely *teacher professional actions*. These authors define professional actions as teacher's acts (physical or verbal) and the permanent "adjustments" in relation to student activity and knowledge at stake. These authors describe their organization and dynamics through the "multi-agenda of entrenched concerns [our traduction]" (*Ibid.*, p.32; schema 1 for an adapted version). The five concerns are:

- *leading the lesson* (organization and coherence of the lesson, through its material, spatial and functional dimensions);
- *atmosphere* (maintaining dialogical spaces);
- *linking* (making connections with what pupils already know or connections between other knowledges);

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<sup>1</sup> Our traduction from Jorro's original notions of « geste du métier » and « geste professionnel ».

– *scaffolding* according to Bruner’s meaning i.e. helping pupils do and say things without doing it for them (Bruner, 1983);

– the targeted *knowledge* (central component).

For us, professional actions are specific, situated, on a given context and moment, and led through didactical intention(s) (that means these “intentions” are more or less with direct and conscious links with the teaching project). It is important to notice now this theoretical framework’s goal is not about to give a binary classification generic/specific we refuse. What seems rightly interesting in the use of this general theoretical framework is that it can be mobilized in order to analyze any classroom session. Therefore, this is interesting in the cross of didactical analysis from different fields, which is the goal of the bigger research in which our collection of data fits. This paper deals with professional actions of beginning teachers in the context of teaching geometry.

### **Focus on beginners**

In this framework, the dynamical organization of professional actions determines teachers’ “postures of scaffolding<sup>2</sup>” some of which can be exaggerated among beginning teachers. The “posture of control”, for example, is frequently observed because they try above all to organize their work in relation to time and space, without taking into account the students’ potential activity. “Linking is rare. Pupils are usually addressed collectively and the atmosphere is relatively tense [our traduction]” (Bucheton & Soulé, 2009, p. 40). Furthermore, Robert and Rogalski (in Vandebrouck, 2013) define teacher’s practices as complex, stable and coherent. According to these considerations, it is therefore relevant to study the practices of teacher since their beginning to better understand the conditions of genesis and development of professional teacher actions. Especially since the generic teaching actions have been identified as being the ones that beginning teachers will try to incorporate into their practices (Jorro, 2002). How do the teacher actions become professional and relevant? What impact do the specificities of teaching geometry have on the implementation and articulation of these actions? What impact on potential students’ learning?

### **The specific context of teaching and learning geometry**

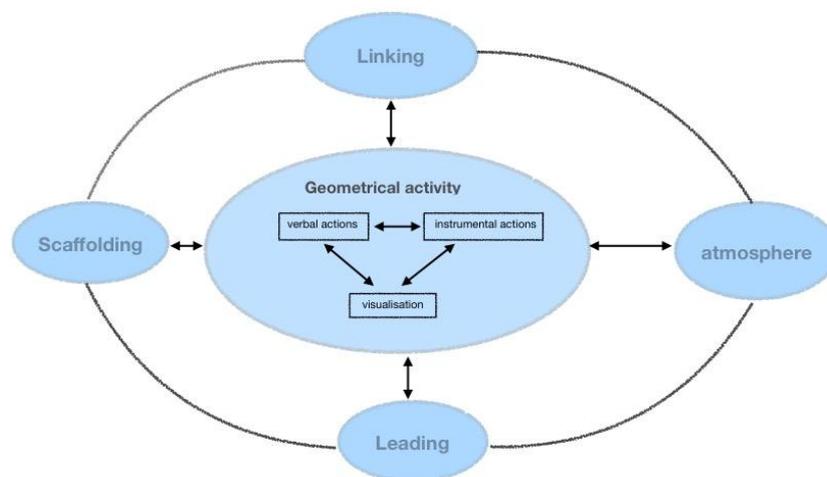
A lot of works relate the difficulties of teaching and learning geometry. Indeed, geometry is unique and complex in terms of the role of material activity (using instrument, manipulation, modeling...), visualization and language for the construction of mathematical concepts, as described in previous CERME (Jones & Al., 2017). We assume in our work there are mutual influences (and not subordinated one to another) between visualization (according to Duval’s meaning, 2005), instrumental action (graphical register) and language (Bulf, Mathé & Miltalal, 2011). In doing so we seek to describe teacher’s actions more precisely in our analysis, taking into account the different manifestations of geometrical concept (graphical register, verbal formulation, coding, physical gesture, etc.). According to Duval’s framework (2005), we refer to the “dimensional deconstruction” to analyze geometrical object at stake in terms of figural units (2D for surface, 1D for line and 0D for point as intersection of lines), and relations between these different units. In

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<sup>2</sup> “Accompaniment, control, letting go, teaching-conceptualization, magician” (Bucheton & soulé, 2009, p. 41)

other words, this is our additional and specific theoretical background to take into account the context of teaching and learning geometry.

The goal of this paper is to highlight the fact that professional actions are formed early (as mentioned at the beginning of this paper) but, depending on the task assigned to students in the context of teaching geometry, that they may hinder understanding of the geometrical concepts under consideration. We try to describe the reasons of these misunderstanding because, precisely, some professional actions could be, on the contrary, relevant in other context of teaching. That's why our theoretical framework seems particularly interesting because it contributes to show clearly the limits of dichotomy genericity / specificity of professional actions in pre and in-service teachers training. We summarize our theoretical framework in the schema 1. The central component (from Bucheton and Soulé' framework) is here the geometrical *knowledge* at stake, and therefore according to our theoretical framework, it is observed in activity through three dimensions: visual, oral and instrumental.



**Schema 1. “multi-agenda of entrenched concerns” (Bucheton and soulé, 2009, p.33) adapted to the context of teaching geometry.**

The specific context of geometry teaching with beginning teachers allow us to highlight obstacles or potential levers to better understanding professional development of teacher. This paper tries to answer to the research questions : How do the specificities of teaching geometry (in terms of visualization, instrumental action and language) have an impact on the implementation and articulation of professional actions (schema 1) ? What impact on potential students' learning?

## **Methodology and results**

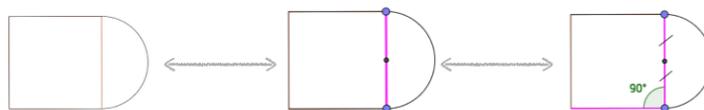
Our corpus is composed of several videos and transcripts of lessons, visit reports, professional writings, interviews, etc. collected during pre-service teachers and during the first years of practice of a dozen of beginning teachers since 2013. In the present contribution we chose to refer to the professional actions of three teachers, Maya, Emilie and Celine observed in 2016 and 2017. We

think these case studies are representative of novice teachers' practices in the context of teaching and learning geometry<sup>3</sup>.

Our analysis methodology is qualitative and based on classical models in the French field of didactics of mathematics, known as *a priori* or *a posteriori* analysis according to the Theory of didactical situations in mathematics (Brousseau, 1997). A *a priori* analysis is an epistemological reasoning which does not have a predictive sense, but instead a causal one; it involves describing various possible (and therefore potentially reproducible) phenomena in teaching session. Our *a posteriori* analysis places contingent facts in the context created by the *a priori* analysis. Furthermore, our data are analyzed in accordance with our theoretical framework, which means we describe geometrical activity (*a priori* and *a posteriori*) through its different manifestations: visual, instrumental or verbal (as already described in previous paragraph). We infer from these analyzes hypotheses in terms of professional actions as we have described in our general theoretical framework (schema 1). We pay attention on the different type of teacher's scaffolding, leading, linking and atmosphere own to these teachers in relation with the geometrical knowledge at stake.

### **Over-scaffolding through different dimensions (verbal / visual / instrumental) of geometrical activity**

This episode is frequently encountered in classes ; it's about talking collectively about a figure on the blackboard. We refer here to a observation occurred in 2017 in Celine's class (with students aged 8 to 9). Students have to reproduce the figure given on the left extremity of the figures 1.



**Figures 1. Different ways of seeing one side of the square**

The different ways of seeing one side of the square as also the diameter of the half-circle<sup>4</sup> is the key to solve this problem. It is necessary to go beyond a first vision as a simple border line between two juxtaposed figures:

- this side is perpendicular to 2 other sides (relationship between 2 objects of dimension 1D);
- this side is a segment, which is also a diameter of the half-circle. The middle of this segment is the center of the circle (different objects 1D and 0D, and their relationships).

These different ways of seeing this “simple” figure are not self-evident because it involves different figural units (lines, points) and different kind of relationships (belonging, middle, perpendicular,

<sup>3</sup> Given what we have observed and analyzed so far in our previous researches and in the corpus for this research (corpus made up of a dozen novice teachers).

<sup>4</sup> « double designation » (Duval, 2014, p.5) of a figural unit.

equal distance...). If we focus on the center of the circle, there is *a priori* a lot of different ways to understand it (without being exhaustive):

- a point belonging to the side of the square (which requires to see a line as a set of – infinite– points, but it is far from being acquired for students of this age);
- the middle of a segment of which the ends are the vertices of the square: here coexist two ways to see points (vertex / end of segment);
- the center of the circle is where we will put one branch of compass ;
- the center is the point located to equidistant from the line (or points) defining the half-circle;
- the center is the junction point of the union of two rays in the same direction (here);
- .....

At the beginning of the session, Celine tries to explain the task by making the students talk about the instrumented actions. It is kind of over-scaffolding without linking the different possible ways of seeing the side of the square and the center of the circle:

Celine: How do I put my compass on my square?

Student: on the board there is a line in the middle to put the starting mine in the middle of the line

Celine: then in the middle of the line you speak about side [She sweeps the side with a hand gesture and points the middle of the side, figure 2] okay what is it in relation with our circle /// you remember where he is the center of the circle? // How is it called? [Sweeps the side of a hand gesture like the moment before from top to bottom] /// all of this / yes it is the diameter / there [gap between the auriculaire and the thumb, figure 3] it is the radius / you remember the center of circle [pointing finger, figure 2] it is the middle of the diameter/ it shares the diameter in 2 radius.



Figure 2. physical gesture of pointing finger

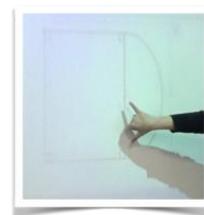


Figure 3. physical gesture of finger spacing

In less than two minutes, there are 9 different oral designations (*square, side, line, diameter, radius, middle of the line, center of the circle, middle of the diameter, this-there*) and 3 different physical actions that all rely on the same graphical sign on the blackboard. The same sweeping movement of the hand sometimes refers to the diameter of the circle or the side of the square or the radius (if the amplitude is shorter). The pointing finger indicates at the same time where to put the branch of the compass, the center of the circle, the middle of the diameter, the middle of the side of the square, the junction between two rays. This kind of scaffolding, both verbal and physical, characterizes the

teacher's will to help student through multiple designations, reformulations,... and as the beginners think they should provide. But this exemple is, in our opinion, representative of potential misunderstandings on the construction of meaning through these teaching actions. Indeed, different ways of thinking of the same objects are consciously mobilized, but it is as if going from one vision to another is self-evident, without linking: we move from the designation of objects to their relationships and their operationalization through instruments. At this student's age all these connections are not yet built. Here we are one of classical teacher interventions in geometry teaching, not especially with novice... The big question is : how to manage the complex specificity of geometrical activity : *the way of seeing a figure, the way of acting* with geometrical tools or not, *the way of speaking* ? We refer here to researches already exposed in previous CERME (Bulf, Mathé, Mithalal, 2011) (Barrier, Hache, Mathé, 2013) ; they proposed different theoretical tools to analyse geometrical activity in this way.

### **Different impacts on students' learning from scaffolding on the necessary and sufficient conditions for building a square**

Two novice teachers, Maya and Emilie, in 2016 prepared together a lesson (for students aged 8 to 9 years old). The students have to reproduce a square of 10 cm of side. At the end of the collective phase, both teachers chose to proceed by "dictation to the adult" that means students gives oral instructions and the teacher executes them to build the figure. An interesting moment happens when three sides of 10 cm and 2 right angles are correctly drawn at blackboard with expected geometrical tools. Both teachers ask to students « do we need set square to close the square ? » which is, in both cases, a spontaneous move. The question is : is it a relevant professional action ?

In Maya's class, she retains the one who talk about the set square to finish the construction. But Maya asks to students about the validity of another student's proposal who suggests to draw the line directly without the set square. This student, Nicolas, is also a student usually in difficulty.

Maya: Would Nicolas's technique have worked? Nicolas can you explain why it would have worked? [...] So you tell me we did not need the set square to draw the last line we could do directly with the rule to draw the last line.

The students do not validate Nicolas's technic because precisely it does not use the set square. On one hand they may reply this because it corresponds to what is worked precisely in this lesson, this is the didactical contract (Brousseau, 1997) and on the other hand probably because Nicolas is a student usually in difficulty... But here teacher's question is about the necessary and sufficient conditions for building a square, which is out of didactical contract for these students at this age. The teacher is stuck because Nicolas is right, it is mathematically correct. Therefore Maya chose to validate it and she concludes with theoretical argument: « As long as I have 3 sides of the same length and 2 right angles », which is, actually out of contract but in the same time it is also an opportunity to value this student (*atmosphere concern*).

Maya: Nicolas' proposal it would have worked / I connected well / I took my rule and my set square to do it but if I had connected this first line that I had done with it, it would have made me too the 2 right angles in the case ok where I already had the 2 right angles and the 3 sides which made the same length. Alright ... With my set

square I did the same thing as Nicolas proposes, I connected the 2 parts of the line, I did it with the square but we could do it directly with the rule .

Whereas in Emilie's class, Emilie also relies on a student's proposal but the student stands on a graphical argument that Emilie resumes directly : « yes you have already drawn both lines you need to connect» «I just have to connect». We stay in a primary school contract strongly linked to graphical register.

## **Conclusion, discussion and perspectives about pre and in-service teacher training**

From the previous paragraph, we pointed out the necessary and sufficient conditions (here to recognize a square) are usually not anticipated by novice teachers and this may have a direct impact on teacher's scaffolding and therefore on student's learning. In one case, students may be confused at the end of the session on the contract at stake about the use of set square whereas in the other case, we stay in a contract in a paradigm of Geometry I (Kuzniak, 2018) that means validation is done within a graphical register.

This paper is also based on other case studies. We described at the beginning of the paper how Celine was overwhelmed by the managing of different dimensions own to geometrical activity (way of speaking, way of seeing and way of acting -with geometrical tools or not) about graphical figure. This is a typical novice's teacher action : novice teachers want to help students (when they give instructions at the beginning of the lesson) with multiple designations, reformulations,... but in the geometrical context, this may involve over-scaffolding through all registers in the same time (graphical, visual, discursive) and brings more confusion than help.

In previous work (Bulf 2016), we described how novice teachers try to play school teacher through the embodiment of « caricatural » teaching actions with an over-leading about rigor on semiotic representation of geometrical objects (vocabulary, coding, or quality of drawing<sup>5</sup>).

We believe these teacher's actions with novice teachers are actually not reserved for novices... That's why our research gives perspectives for pre-service and in-service teacher training to better understand the conditions of professional development in geometry teaching but not only. Our research in progress crosses results with other fields. We think this kind of research gives the opportunity to discuss the limit about a theoretical framework based on genericity of teaching actions. Indeed, in our different examples we may recognize teachers' actions shared by teacher community (*have students talk about the validity and rigor of their production; to explain in different ways the same thing ; to compare opinions between students etc.*) but it seems important to highlight the fact that these actions may be rich in potential misunderstandings in the context of teaching geometry. Even more, our study, in the context of teaching and learning geometry, suggests that it makes no sense to consider teacher's actions from a generic point of view because

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<sup>5</sup> This is quite typical for beginning teacher in France. We suppose that may come from the fact the competitive exam that these young teachers had to pass requires a theoretical and deductive hypothetico reasoning of the Euclidean geometry.

each teaching actions are always specific and connected to a specific knowledge which requires its own and specific actions. This opens the more theoretical discussion of theoretical frameworks that seek to model teaching activities.

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